



# DOE FEMP First Thursday Seminar

## *New Lighting Technologies*

### Learner Guide

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#### *Short Description*

This seminar will illustrate the benefits of new lighting technologies and discuss the best situations for deployment, correct applications, and measurement of energy savings. Technologies will include spectrally enhanced light (SEL) and exterior solid-state lighting (SSL) technology.

This course is offered live on February 02, 2012 and archived for 24/7 viewing after the live training event.

The following topics will be covered:

- Exterior Solid State Lighting (SSLs)
- Spectrally Enhanced Lighting (SELs)
- Selection and implementation options and decisions
- Applications, benefits, and issues
- Design-related issues, installations, and common myths
- Measuring savings and benefits
- Project examples

#### *Core Competency Areas Addressed in the Training*

##### **Energy/Sustainability Managers**

- Industry Trends
- Building Technologies
- Improving Energy Efficiency

##### **Facility Managers**

- Industry Trends
- Building Technologies

- Managing Facility Projects

### **Operating Engineers/Building Technicians**

- Lighting Systems
- Adjust/Replace Lighting

### *Expected Results for Those Completing this Training*

It is expected that individuals completing this training will implement lighting solution projects that increase energy efficiency in Federal and Federal contractor facilities thereby reducing greenhouse gas emissions. Specifically, the individual completing the training will:

1. Select optimal lighting replacement projects based on quality baseline data
2. Review a number of potential lighting technologies and select the best solution for a particular application based on life-cycle costs, design and installation and feasibility
3. Determine how project results will be measured
4. Locate DOE and industry resources to support decision-making processes.

### *Lighting Resources*

To learn more about lighting, check these resources.

- Spectrally Enhanced Lighting  
[http://www1.eere.energy.gov/buildings/m/spectrally\\_enhanced.html](http://www1.eere.energy.gov/buildings/m/spectrally_enhanced.html)
- Energy-Efficient Lighting Guidance  
[http://www1.eere.energy.gov/femp/technologies/eep\\_lighting\\_guidance.html](http://www1.eere.energy.gov/femp/technologies/eep_lighting_guidance.html)
- Solid-State Lighting  
<http://www1.eere.energy.gov/buildings/ssl/>
- Energy Savers: Lighting & Daylighting  
[http://www.energysavers.gov/your\\_home/lighting\\_daylighting/index.cfm/mytopic=11970](http://www.energysavers.gov/your_home/lighting_daylighting/index.cfm/mytopic=11970)
- DOE – Induction Lighting  
<http://www.mhtlighting.com/news/department-of-energy-doe-induction-lighting-an-old-lighting-technology-made-new-again/>

## *Glossary of Lighting Technology Terms*

**Backlight** Light emitted in the direction of the luminaire. Backlight creates light trespass onto adjacent sites. Backlight is a component of the new TM-15-07 based BUG rating system, which replaces the older cutoff classification system.

**Candela** A measure of luminous intensity, or power emitted by a light source in a particular direction. A common candle emits light with a luminous intensity of roughly one candela.

**Chromaticity** A measure of color quality as reflected in the CIE (International Commission on Illumination) 1931 color chart, which provides x/y coordinates of reds, greens and blues (RGB). The color of white LEDs, as measured in Kelvin (K), is reflected in a narrow strip at the center of the CIE chart where RGB combinations create various shades of white. See correlated color temperature (CCT).

**Color Rendering Index (CRI)** A quantitative measure of the ability of a light source to reproduce the colors of illuminated objects accurately when compared to a reference light source, such as an incandescent lamp.

**Cones** Photoreceptor cells in the retina of the eye that function best in relatively bright light. See rods.

**Correlated Color Temperature (CCT)** is the measure used to describe the relative color appearance of a white light source. CCT indicates whether a light source appears more yellow/gold/orange or more blue, in terms of the range of available shades of “white.” CCT is given in kelvins (unit of absolute temperature).

**Efficiency** is a general term for the amount of useful work per quantity of energy. See fixture efficiency, LED efficiency, optical efficiency, and source efficiency.

**Electronic ballast and ballast factor (BF)**—To improve energy efficiency, SEL technology usually includes Premium electronic ballasts designed to work with the new T8 or T5HO fluorescent lamps. Ballast factor (BF) is the factor applied to the rated lumens of the lamps and is a function of the lamp/ballast combination employed. When dimming ballasts are used, the dimmed BF should be used in all calculations.

**Fitted Target Efficiency (FTE)** A system created under the draft Energy Star program for outdoor SSL luminaires used to measure how efficiently a luminaire illuminates its targeted area. The FTE calculator uses a selected LM-79-08 absolute photometry IES file for a desired luminaire, and projects the luminaire output onto a grid along the area to be illuminated, such as a street or parking garage floor.

**Fixture (Or System) Efficiency** A measure of luminaire efficiency that focuses on the performance of the combined luminaire, including source efficiency, driver

efficiency, and optical efficiency. Fixture efficiency reflects the amount of useful light delivered by the luminaire divided by the power required to operate it.

**Foot-Candle** A measure of illuminance or light intensity. A foot-candle reflects the amount of illumination the inside surface of a 1-foot radius sphere receives from a point source of one candela in the center of the sphere. A foot-candle is also equal to one lumen per square foot.

**Fully-Rated Life** An achievement by a device or system that provides useful service for as long as the device or system manufacturer projects. For example, white LEDs are commonly marketed with 50,000 hour fully-rated lives, where the end of life is defined by the point at which the LED fails to deliver at least 70% of initial lumen output.

**General illumination** is a term used to distinguish between lighting that illuminates tasks, spaces, or objects from lighting used in indicator or purely decorative applications. In most cases, general illumination is provided by white light sources, including incandescent, fluorescent, high-intensity discharge sources, and white LEDs. Lighting used for indication or decoration is often monochromatic, as in traffic lights, exit signs, vehicle brake lights, signage, and holiday lights.

**Heat Dissipation** The intentional transition of thermal energy from a hotter object (such as a sensitive electronic device) to a cooler object. Heat dissipation is achieved with LEDs primarily by mounting them on heat sinks made on high-quality aluminum and other alloys.

**Heat Sink** An object that absorbs and dissipates heat from another object using thermal contact (either direct or radiant).

**High Power LEDs** LEDs designed to operate at several hundred milliamps and a watt or more of power. Since these devices create substantial heat, which would destroy the unit if special steps were not taken, specialized heat dissipation technologies must be employed.

**Kelvin (K)** A thermodynamic (absolute) temperature scale, based on a measure of absolute zero—the absence of all thermal energy—at zero K. The Kelvin is described without reference to degrees, and is written without a degree symbol.

**L70** An abbreviation for 70% of initial lumens levels delivered from an LED, which is a common definition of the useful life of an LED.

**LED** Acronym for light emitting diode.

**LED Array** A predetermined pattern of a number of LEDs mounted on a printed circuit board (PCB) or other surface, which is capable of producing light when powered.

**LED Efficiency** A measure of the light output of an LED device, generally measured in lumens, divided by the power, generally measured in watts, required to operate the device. This relationship, lumens per watt, is a key measure of LED performance.

**Light Emitting Diode (LED)** An electronic light source derived from a semiconductor diode possessing unidirectional electric current properties—in other words, diodes are one-way switches. When a voltage is applied in the forward direction, electrons from one side of the p/n junction recombine with holes on the other side of the junction, and energy is released in the form of light. Light-emitting diodes (LEDs) are based on inorganic (non-carbon based) materials.

**LM-79** Popular name for an LED measurement standard, the full title of which is IESNA LM-79-08, Approved Method for the Electrical and Photometric Measurements of Solid-State Lighting Products. This standard provides guidelines to photometric labs for the proper and repeatable measurement of LED lighting systems.

**LM-80** Popular name for an LED measurement standard, the full title of which is LM-80-08, Approved Method for Measuring Lumen Maintenance of LED Light Sources. This standard provides guidelines to LED manufacturers for measuring lumen maintenance, or the level of light output maintained over predetermined time periods.

**Lumens Per Watt (LPW)** The ratio of light produced by an LED device, measured in lumens, divided by the power, measured in watts, required to operate the device. LPW is a key measure of LED performance.

**Luminaire** A lighting fixture complete with lamp, optical components used to direct light, housing, and power supply (e.g., a fluorescent ballast or LED driver).

**Luminous efficacy** is the most commonly used measure of the energy efficiency of a light source. It is stated in lumens per watt (lm/W), indicating the amount of light a light source produces for each watt of electricity consumed. For white high-brightness LEDs, luminous efficacy published by LED manufacturers typically refers to the LED chip only, and doesn't include driver losses.

**Lux** A metric measure of illuminance, or the apparent intensity of light hitting or passing through a surface.

**Mercury Vapor** Historically popular type of high intensity discharge (HID) lamp offering a relatively warm correlated color temperature (CCT), high levels of efficiency, and long life, but only modest levels of color rendering index (CRI). Due to environmental concerns, most mercury vapor luminaires are no longer available, but mercury vapor lamps remain available for existing luminaires.

**Mesopic Vision** A combination of photopic vision and scotopic vision in environments with low, but not completely dark, light levels.

**Metal Halide (MH)** A popular type of high intensity discharge (HID ) lamp offering a relatively cool correlated color temperature (CCT) and long life, but only modest levels of efficiency and color rendering index (CRI).

**Optical Efficiency** A measure of luminaire efficiency that focuses on the performance of optical components. Specifically, optical efficiency is the ratio of lighting delivered by a luminaire to the light produced by the lamps.

**Organic light-emitting diodes (OLEDs)** are based on organic (carbon based) materials. In contrast to LEDs, which are small point sources, OLEDs are made in sheets which provide a diffuse area light source. OLED technology is developing rapidly and is increasingly used in display applications such as cell phones and PDA screens. However, OLEDs are still some years away from becoming a practical general illumination source. Additional advancements are needed in light output, color, efficiency, cost, and lifetime.

**P/N Junction** The border region in a semiconductor device formed by placing P-type (or materials carrying a positive charge) and N-type (or materials carrying a negative charge) semiconductor materials together in close proximity. It is the location in an LED where light is created, as well as the location inside the LED where heat is created

**Phosphor conversion** is a method used to generate white light with LEDs. A blue or near-ultraviolet LED is coated with a yellow or multi-chromatic phosphor, resulting in white light.

**Phosphors** A substance that exhibits phosphorescence, which is the process of glowing occurring after exposure to energized particles. Many white LEDs are produced by combining GaN or InGaN LEDs, which produce blue light, with YAG (yttrium aluminum garnet) phosphors. See white phosphor LED.

**RGB** stands for red, green, and blue, the three primary colors of light. When the primaries are mixed, the resulting light appears white to the human eye. Mixing the light from red, green, and blue LEDs is one way to produce white light. The other approach is known as phosphor conversion. [

**Solid-state lighting (SSL)** technology uses semi-conducting materials to convert electricity into light. SSL is an umbrella term encompassing both light-emitting diodes (LEDs) and organic light emitting diodes (OLEDs).

**Source Efficiency** A measure of luminaire efficiency that focuses on the performance of lamps. The source efficiency of LEDs is currently about equal with many fluorescent and HID sources, but the directional nature of light produced from LEDs delivers substantially higher fixture (or system) efficiency than traditional sources.

**Spectrally Enhanced Lighting (SEL)** is founded on the principle that daylight, or 'white' light, is perceived in a sharper manner by the human eye. Based on this fact,

**SEL** technology utilizes a higher color temperature to create a more natural, brilliant and intense level of lighting.

**T8**—A type of fluorescent lamp. The “T” means it is tubular in shape and the “8” means the diameter is eight-eighths of an inch, or 1 inch. A T12 lamp is twelve-eighths of an inch, or 1.5 inches thick. T8 lamps have a better CRI and are more efficient than T12 lamps.

**Thermal Efficiency** A measure of luminaire efficiency that focuses on the ability of the luminaire system to transfer heat from sensitive components, such as LEDs, to the outside environment. High levels of thermal efficiency are made possible through the use of high-quality components (such as LEDs with low thermal resistance) and materials (such as aluminum alloys with low thermal resistance), as well as intelligent product designs.

**Uplight** Light emitted from the luminaire directly into the sky which causes artificial sky glow and generally represents wasted energy. Uplight is a component of the new TM-15-07-based BUG rating system, which replaces the older cutoff classification system.

**Useful Life** The length of time an asset or device can be used without major refurbishing. In lighting, the useful life of lamps is typically stated at 70% of initial lumens since it is difficult to perceive this reduction in light output.

**White Phosphor LEDs** Combinations of InGaN (indium gallium nitride) semiconductor material—which produces blue light—and YAG (yttrium aluminum garnet) phosphors create white light. Other LED systems deliver white light by combining red, green and blue (RGB)

**850**—A number that combines the CCT and CRI into one number. The “8” in 850 refers to a CCT of 5000K. A 735 lamp would have a CRI in the 70s and a CCT of 3500K.